WATER RESISTANT INK JET RECORDABLE SUBSTRATE

This application is a continuation-in-part application of U.S. Patent Application Serial No. 10/411,311 filed on April 11, 2003, which is a conversion of United States Provisional Patent Application Serial No. 60/373,957 filed on April 19, 2002.

The present invention is directed to an ink jet recordable substrate. In particular, the present invention relates to a water-resistant coating composition for an ink jet recordable substrate, a method for preparing the coating composition and a method of applying said coating composition to produce a water-resistant ink jet recordable substrate.

It is known in the art to employ various paper treatment methods to improve the quality of ink jet prints thereon. However, problems have been experienced when the imaged-sheet comes into contact with water; the image may migrate through the sheet to the other side. In some instances, the show-through of the image on the back side of the paper has more ink than the front side. Further, paper treatment methods which improve inter-color bleed problems in color ink jet images may heighten the severity of show-through of the image.

It is also known in the art to size cellulosic-based paper with sizing components for the purpose of reducing the penetration of liquids into the substrate. "Internal sizing" may include the introduction of a material into the pulp during the paper making operation. "Surface sizing" may include the application of dispersions of film-forming substances such as converted starches, gums, and modified polymers to previously formed paper. When used to print with an ink jet printer containing predominantly water based inks, internal and surface sized papers often yield imaged papers which curl into tubes.

Thus, it would be desirable to develop an ink jet recordable substrate that does not exhibit the aforementioned problems.

U.S. Patent No. 5,709,976 discloses a method for coating a paper substrate with a hydrophobic barrier layer and an image- receiving layer. U.S. Patent No. 6,140,412 discloses a method for coating paper with an aqueous cationic polyurethane resin solution.

In addition to paper printing substrates, polyolefin based printing substrates in the form of a microporous material sheet were developed and are known in the art. For example, U.S. Patents 4,861,644 and 5,196,262 disclose microporous material sheets which include a matrix of linear ultrahigh molecular weight polyolefin, a large proportion of finely divided water-insoluble siliceous filler, and interconnecting pores. However, inks used for inkjet printing may coalesce on the surface of the polyolefin based printing substrates.

U.S. Patent No. 6,025,068 discloses a method for coating a microporous polyolefin substrate with a composition including a binder dissolved or dispersed in a volatile aqueous liquid medium. The binder includes a film-forming organic polymer of a water-soluble poly(ethylene oxide) and a water-soluble or water-dispersible crosslinkable urethane-acrylate hybrid polymer. However, ink jet recordings on these coated substrates lack the sharpness and vibrancy which is desired.

Japanese Patent (JP) 2001-184881 discloses a coating composition that includes a nonionic or anionic polyurethane and the reaction product of a monomeric secondary amine and epichlorohydrin. However, when subsequently contacted with water, the monomeric amine adduct can solubilize, which may result in a blurred image.

Further, United States Patent 6,020,058 discloses an acrylic composition and United States Patent 6,025,068 discloses a urethane-acrylic co-polymer. These patents are incorporated herein by reference.

Moreover, patent application having U.S. Serial No. 60/309,348 filed August 1, 2001, discloses a two-component water-resistant coating composition for use with a microporous substrate; and patent application having U.S. Serial No. 60/317,113 filed September 5, 2001, discloses a method of processing a coated microporous substrate. Both of these patent applications are incorporated herein by reference.

Thus, there is a need in the art for an ink jet recordable substrate that is durable, water resistant and able to record sharp images when an ink jet printing ink is applied thereto.

SUMMARY OF THE INVENTION

The present invention is directed to a water-resistant coating composition for ink jet recordable substrates. The water-resistant coating composition includes:

(a) an aqueous polyurethane dispersion;

(b) an aqueous solution of a cationic nitrogen-containing polymeric dye fixative compound; and

(c) an acrylic polymer,

wherein the coating composition has a pH of 7 or less.

The present invention is also directed to a method of coating an ink jet recordable substrate in which an ink jet recordable substrate is provided and the above-defined coating composition is applied to the substrate.

The present invention is further directed to an ink jet recordable substrate which includes a substrate having at least one side, and to at least one side of the substrate is applied a coating layer of the above described coating composition.

DETAILED DESCRIPTION OF THE INVENTION

Unless otherwise indicated, all numbers or expressions referring to quantities of ingredients, reaction conditions, etc. used herein are to be understood as modified in all instances by the term "about."

Unless otherwise indicated, all references to (meth)acrylic, (meth)acrylate and (meth)acrylamide monomers is meant to include both the methacrylic and acrylic species.

Any polyurethane that may be dispersible in water is suitable for use in the present coating composition. Such polyurethanes include anionic, cationic and nonionic polyurethanes. The co-mixing of anionic polymers and cationic polymers often produces a polysalt which is typically insoluble in water and other solvents. In the present invention, it has been discovered that an anionic polyurethane dispersion may be combined with a cationic nitrogen-containing polymer to form a stable aqueous dispersion which can be useful as a coating composition for an ink jet recordable substrate.

An aqueous dispersion of polyurethane resin comprising particles of a polyurethane polymer dispersed in an aqueous medium can be used in the present invention.

The polyurethane for use in the present invention can be prepared by a variety of methods known in the art. For example, a polyisocyanate can be reacted with a polyol to form a prepolymer, such as an isocyanate-terminated prepolymer. As used herein and the claims, the term "polyisocyanate" refers to a compound with more than one isocyanate group, such as a diisocyanate. Non-limiting examples of suitable diisocyanates for use in the present invention include toluene diisocyanate, hexamethylene diisocyanate, isophorone diisocyanate and dicyclohexyl methane diisocyanate. Non-limiting examples of suitable three or more functional isocyanates include the reaction products of diisocyanates with polyols such as trimethylol propane, glycerol and pentaerythritol. A suitable polyisocyanate for use in the present invention can include but is not limited to Desmodur which is commercially available from Bayer.

As used herein and in the claims, the term "polyol" refers to a compound with more than one hydroxyl group. Non-limiting examples of suitable polyols for use in the present invention include polyols such as those from which the polyisocyanate can be prepared, polyester polyols and polyether polyols.

The reaction of the polyisocyanate and polyol can be carried out in the presence of an organic solvent. Suitable solvents can include but are not limited to n-methyl pyrrolidone, tetrahydrofuran or glycol ether.

In an embodiment, the prepolymer can be reacted with a di-hydroxyl compound having an acid group, such as dimethylol propionic acid, to produce a polyurethane with at least one pendant acid group. The acid group can include a carboxylic acid group or a sulfonic acid group. The polyurethane having a pendant acid group can then be reacted with a base to produce an anionic polyurethane. The anionic polyurethane dispersions of the present invention generally can be dispersed in a base which ionizes the acidic groups of the polymer and stabilizes the dispersion. The base can be selected from the group consisting of an inorganic base, ammonia, amine and mixtures thereof.

Non-limiting examples of suitable anionic polyurethanes for use in the present invention can include anionic polyurethanes based on aromatic polyether polyurethanes, aliphatic polyether polyurethanes, aromatic polyester polyurethanes, aliphatic polyester polyurethanes, aromatic polycaprolactam polyurethanes, and/or aliphatic polycaprolactam polyurethanes. Examples of suitable anionic polyurethane dispersions that can be used in the present invention can include but are not limited to those marketed under the trade name WitcoBond® which are commercially available from Crompton Corporation, Greenwich, Connecticut.

A cationic polyurethane dispersion for use in the present invention can be prepared by a variety of methods known in the art. For example, United States Patent 3,470,310 discloses a method which includes the preparation of water dispersions of polyurethanes which contain salt-type groups bonded into the polyurethane. United States Patent 3,873,484 discloses aqueous dispersions of polyurethanes prepared from a quaternized polyurethane prepolymer. United States Patent 6,221,954 discloses a method for preparing a polyurethane prepolymer in which a N-monoalkanol tertiary amine is reacted with an alkylene oxide in the presence of a strong acid. The relevant portions of these patents are herein incorporated by reference.

In an embodiment, the prepolymer can be reacted with a di-hydroxyl compound having an amine group, such as a secondary or tertiary amine, to produce a polyurethane with at least one pendant amine group. Non-limiting examples of a di-hydroxyl compound having an amine group can include polyamines such as ethylene diamine, isophorone diamine and diethylene triamine. The polyurethane having a pendant amine group can then be reacted with an acid to produce a cationic polyurethane.

Suitable cationic polyurethanes for use in the present invention can include but is not limited to those marketed under the trade name WitcoBond (i.e., W213, W215 and X051) which are available from Crompton Corporation, Greenwich, Connecticut.

In another embodiment of the present invention, the prepolymer can be reacted with a diol having a polyalkylene oxide chain, to produce a polyurethane

backbone with a polyalkylene glycol pendant chain. The polyurethane having a polyalkylene glycol pendant chain can be reduced with water to produce a nonionic polyurethane.

Suitable nonionic polyurethanes for use in the present invention can include but is not limited to those marketed under the trade name WitcoBond (i.e., W320) which are available from Crompton Corporation, Greenwich, Connecticut.

In a non-limiting embodiment, a vinyl or ethylenic unsaturated isocyanate prepolymer or vinyl or ethylenic unsaturated polyurethane can be reacted with a vinyl or ethylenic unsaturated acid species, such as acrylic acid or methacrylic acid, in a free radical synthesis to form a carboxylic acid pendant polyurethane. The acid pendant polyurethane can be reacted with a base, such as those aforementioned, to form an anionic polyurethane.

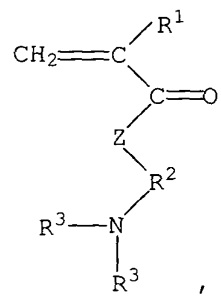
Further, the prepolymer can be dispersed in water in the presence of a base and then chain extended by adding a polyamine. In a non-limiting embodiment, the prepolymer can be chain-extended in an organic solvent solution and the resulting polyurethane polymer can be dispersed in water in the presence of a base.

In alternate non-limiting embodiments, the aqueous polyurethane dispersion can contain up to 70 wt.%, or up to 65 wt.%, or up to 60 wt.%, or up to 50 wt.% of the polyurethane. The aqueous polyurethane dispersion can include at least 1 wt.%, or at least 5 wt.%, or at least 10 wt.%, or at least 20 wt.% polyurethane. The amount of polyurethane in the aqueous polyurethane dispersion can vary widely. However, the amount should not be so high as to cause the dispersion itself or the mixture with the nitrogen-containing polymer to be unstable; and the amount should not be so low that the coating composition does not provide sufficient water and rub resistance or that the dispersion itself becomes unstable. The polyurethane can be present in the aqueous polyurethane dispersion in any range of values inclusive of those stated above.

In addition to an aqueous polyurethane dispersion, a coating composition of the present invention, includes an aqueous solution of a cationic nitrogen-containing polymeric dye fixative compound. In a non-limiting embodiment, the

aqueous solution of a cationic nitrogen-containing polymer suitable for use in the present invention can have a pH of 7 or less, or a pH of 6 or less, or 5 or less, to ensure that at least a portion of the nitrogen atoms carry at least a portion of a cationic charge. In a further non-limiting embodiment, the coating composition of the present invention can also have a pH 7 or less, or 6 or less, or 5 or less.

Any nitrogen-containing polymer in which at least a portion of the nitrogen atoms carry at least a portion of a cationic charge at a pH within the aforementioned range can be useful in the present invention. Non-limiting examples of suitable cationic nitrogen-containing polymers for use as a dye fixative include but are not limited to polymers that include one or more monomer residues derived from one or more of the following nitrogen-containing monomers:



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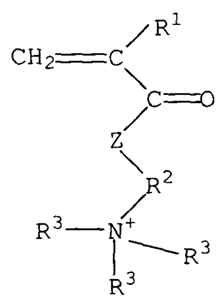

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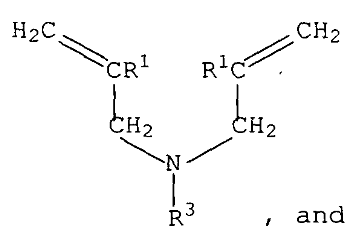

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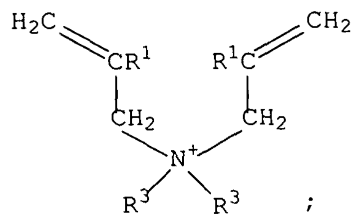
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where R^1 represents independently for each occurrence H or C_1 to C_3 aliphatic; R^2 represents independently for each occurrence a divalent linking group selected from C_2 to C_{20} aliphatic hydrocarbon, polyethylene glycol and polypropylene glycol; R^3 represents independently for each occurrence H, C_1 to C_{22} aliphatic hydrocarbon or a residue from the reaction of the nitrogen with epichlorohydrin; Z is selected from –O- or –NR^4-, wherein R^4 represents H or CH_3; and X represents a halide or methylsulfate.

Non-limiting examples of suitable cationic nitrogen-containing monomers for use in the present invention can include but are not limited to dimethyl aminoethyl (meth)acrylate, (meth)acryloyloxyethyl trimethyl ammonium halides, (meth)acryloyloxyethyl trimethyl ammonium methylsulfate, dimethyl aminopropyl (meth)acrylamide, (meth)acrylamidopropyl trimethyl ammonium halides,(meth)acrylamidopropyl trimethyl ammonium methylsulfate, diallyl amine, methyl diallyl amine, and diallyl dimethyl ammonium halides.

In a non-limiting embodiment, the cationic nitrogen-containing polymers can contain one or more additional monomer residues. An additional monomer residue can be selected from any polymerizable ethylenically unsaturated monomer that when copolymerized with a nitrogen-containing monomer, can result in a polymer that is at least partially soluble in water. As used herein and in the claims, "partially soluble" means at least 0.1 gram of the polymer can be dissolvable in water when 10 grams of the polymer is added to 1 liter of water and mixed for 24 hours.

Non-limiting examples of monomers that can be copolymerized with the nitrogen-containing monomers include but are not limited to (meth)acrylamide, n-alkyl (meth)acrylamides, (meth)acrylic acid, alkyl esters of (meth)acrylate, glycol esters of (meth)acrylic acid, polyethylene glycol esters of (meth)acrylic acid, hdroxyalkyl (meth)acrylates, itaconic acid, alkyl ethers of itaconic acid, maleic

acid, mono- and di-alkyl esters of maleic acid, maleic anhydride, maleimide, aconitic acid, alkyl esters of aconitic acid, allyl alcohol and alkyl ethers of allyl alcohol.

In a further non-limiting embodiment, a nitrogen-containing polymer for use in the present invention, can be a homopolymer of a nitrogen-containing monomer or it can be a copolymer of one or more nitrogen-containing monomers. A nitrogen-containing polymer can also be a copolymer of one or more polymerizable ethylenically unsaturated monomers, or one or more nitrogen-containing monomers, or mixtures thereof. In alternate non-limiting embodiments, when a nitrogen-containing polymer includes one or more other polymerizable ethylenically unsaturated comonomers, the nitrogen-containing polymer can include not more than 70 mol%, or not more than 50 mol%, or not more than 25 mol%, or not more than 10 mol% of the nitrogen-containing monomer. The amount of nitrogen-containing monomer used can depend upon the polyurethane component used in the present coating composition. When the amount of the nitrogen-containing monomer in the nitrogen-containing polymer is too high, the resulting mixture of the nitrogen-containing polymer and polyurethane dispersion can be unstable. The application of an unstable mixture to an ink jet recordable substrate can be difficult.

When the nitrogen-containing polymer includes one or more other polymerizable ethylenically unsaturated comonomers, the nitrogen-containing polymer can include at least 0.1 mol%, or at least 1.0 mol%, or at least 2.5 mol%, or at least 5.0 mol% of the nitrogen-containing monomer. When the amount of nitrogen-containing monomer in the nitrogen-containing polymer is too low, the nitrogen-containing polymer may not provide adequate dye fixative properties and a recorded ink image on the coated substrate can lack the desired water and rub fastness properties.

A nitrogen-containing monomer may be present in the nitrogen-containing polymer in any range of values inclusive of those stated above. The one or more other polymerizable ethylenically unsaturated monomers can be present in an amount sufficient to bring the total percentage to 100 mol%.

In a non-limiting embodiment of the present invention, a nitrogen-containing polymer can comprise an aqueous solution. In this embodiment, the aqueous solution can include at least 5 wt.%, or at least 10 wt.%, or at least 15 wt.% of the nitrogen-containing polymer and not more than 50 wt.%, or not more than 45 wt.%, or not more than 40 wt.% of the nitrogen-containing polymer. When the concentration of the nitrogen-containing polymer is too low it may not be economical for use in commercial applications and can be too dilute to provide optimum ratios with the polyurethane component. When the concentration is too high, the viscosity of the solution can increase and result in handling difficulties in a commercial environment. In a non-limiting embodiment, the nitrogen-containing polymer can include a solution of polyamide amines reacted with epichlorohydrin, available under the trade name CinFix by Stockhausen GmbH & Co. KG, Krefeld, Germany.

The coating composition of the present invention includes an acrylic polymer. In a non-limiting embodiment, the acrylic polymer can be selected from anionic, cationic and nonionic acrylic polymers. In a non-limiting embodiment, the acrylic polymer can include a cationic acrylic polymer. Non-limiting examples of suitable cationic acrylic polymers can include polyacrylates, polymethacrylates, polyacrylonitriles and polymers having monomer types selected from the group consisting of acrylonitrile, acrylic acid, acrylamide and mixtures thereof.

The cationic acrylic polymer can be prepared by a variety of methods known in the art. In a non-limiting embodiment of the present invention, a cationic acrylic polymer can be synthesized via a free radical solution polymerization from monomer types butyl acrylate, methyl methacrylate and 2-(tert-butylamino)ethyl methoacrylate. The molar equivalent of butyl acrylate can be from 0.10 to 0.95, or from 0.15 to 0.75; the molar equivalent of methyl methacrylate can be from 0.10 to 0.85, or from 0.15 to 0.70; and the molar equivalent of 2-(tert-butylamino)ethyl methyacrylate can be from 0.10 to 0.25, or from 0.12 to 0.20. The reaction mixture can be treated with acid such that the pH is within a range of from 4.0 to 7.0. The mixture then can be diluted with water and solvent stripped. Non-limiting examples of suitable acids for use in the

treatment step can include any acid which can function as a solubilizing or dispersing agent to produce a stable dispersion of a cationic polymer. Non-limiting examples of suitable solvents for use in the stripping process can include isopropanol and methyisobutyl ketone (MIBK).

In a non-limiting embodiment of the present invention, the molar equivalent of the butyl acrylate, methyl methacrylate and 2-(tert-butylamino)ethyl methacrylate, can be 0.219 to 0.621 to 0.160, respectively.

In another non-limiting embodiment, the cationic acrylic polymer for use in the present invention can have a number average molecular weight of from 1500 to 8150, or from 2900 to 7125.

The ink jet recordable substrate coating composition of the present invention includes a mixture of an aqueous solution of a nitrogen-containing polymer, an aqueous polyurethane dispersion, and an acrylic polymer. In a non-limiting embodiment, the mixture can include from 20 wt.% to 75 wt.%, or from 25 wt.% to 70 wt.%, or from 30 wt.% to 60 wt.% of the aqueous polyurethane dispersion. The mixture can also include from 5 wt.% to 75 wt.%, or from 15 wt.% to 70 wt.%, or from 30 wt.% to 65 wt.% of an aqueous solution of the nitrogen-containing polymer. The mixture can also include from 1 wt.% to 75 wt.%, or from 20 wt.% to 60 wt.%, or from 25 wt.% to 50 wt.% of an acrylic polymer. The weight percentages are based on the total weight of the ink jet recordable substrate coating composition.

In a non-limiting embodiment of the present invention, water can be added to the mixture of nitrogen-containing polymer, polyurethane and acrylic polymer. When water is added to the mixture, the resulting ink recordable substrate coating composition can have a total resin solids of from 5 wt.% to 35 wt.%, or from 5 wt.% to 20 wt.%, or from 5 wt.% to 15 wt.% based on the total weight of the ink recordable substrate coating composition. A total resin solids that is too high, can cause the viscosity of the coating composition to increase such that the resulting penetration of the coating composition to the substrate can be less than desired. A total resin solids that is too low, can cause the viscosity of the coating composition to decrease such that the resulting penetration of the coating to the substrate can be less than desired. In a non-

limiting embodiment, the viscosity of the coating composition can be less than 500 cps, or less than 400 cps and at least 10 cps, or at least 25 cps when measured using a Brookfield viscometer at 25°C.

In a non-limiting embodiment, the coating composition of the present invention can also include other additives typically known in the art. Non-limiting examples of suitable additives can include surfactants, such as nonionic, cationic, anionic, amphoteric and zwiterionic surfactants; rheology modifiers, such as polyvinyl alcohols, polyvinyl pyrrolidones, polyethylene oxides, polyacrylamides, natural and synthetic gums; biocides, such as a blend of 5-chloro-2-methyl-4-isothiazoline-3-one and 2-methyl-4-isothiazolin-3-one available commercially by the trade name Kathon, from Rohm and Haas Co., 2-hydroxypropylmethane thiosulfonate, and dithiocarbamates; and coupling agents, such as titanium, silane-type, trisodium pyrophosphate.

The pH of the coating composition of the present invention can be less than 7, or less than 6, or less than 5. It is believed that when the pH is outside of these ranges, the cationic polymeric dye fixative compound may not carry a sufficient cationic charge to perform its intended function. Further, it is believed that on certain substrates, the wetting action of the coating composition can be improved when the pH is within the aforementioned ranges. In a non-limiting embodiment, for commercial applications, the coating composition can have pH greater than 2.

The present invention is also directed to a method of preparing the ink jet recordable substrate coating composition of the present invention. In a non-limiting embodiment, the method can include combining an aqueous solution of a nitrogen-containing polymer, an aqueous polyurethane dispersion, and an acrylic polymer. In a non-limiting embodiment, sufficient mixing can be maintained during the addition step to produce a homogeneous mixture.

The present invention is further directed to a method of coating an ink jet recordable substrate. In a non-limiting embodiment, the method can include the steps of:

(a) providing an ink recordable substrate having at least one side;

(b) providing the coating composition described above; and

(c) applying the coating composition to at least one side of the ink recordable substrate.

Any ink jet recordable substrate known in the art can be used in the present invention. As a non-limiting example, the substrate can be any cellulosic-based paper. In another non-limiting embodiment, the ink recordable substrate can be a microporous material substrate. A non-limiting example of such a microporous substrate can be one having at least one surface and which includes:

(a) a matrix comprising a polyolefin;

(b) particulate siliceous filler distributed throughout the matrix; and

(c) a network of pores, wherein the pores can constitute at least 35 percent by volume of the microporous material substrate.

Suitable polyolefins for use in the present invention can include a wide variety known in the art. In a non-limiting embodiment, the polyolefin can comprise a polyethylene and/or a polypropylene. In a further non-limiting embodiment, the polyethylene can be a linear high molecular weight polyethylene having an intrinsic viscosity of at least 10 deciliters/gram and the polypropylene can be a linear high molecular weight polypropylene having an intrinsic viscosity of at least 5 deciliters/gram.

Intrinsic viscosity can be measured using a variety of methods known to the skilled artisan. As used herein and in the claims, intrinsic viscosity can be determined by extrapolating to zero concentration the reduced viscosities or the inherent viscosities of several dilute solutions of the polyolefin wherein the solvent is freshly distilled decahydronaphthalene to which 0.2 percent by weight, 3,5-di-tert-butyl-4-hydroxyhydrocinnamic acid, neopentanetetrayl ester [CAS Registry No. 6683-19-8] has been added. The reduced viscosities or the inherent viscosities of the polyolefin can be ascertained from relative viscosities obtained at 135°C using an Ubbelohde No. 1 viscometer.

In alternate non-limiting embodiments, on a coating-free, printing ink free, impregnant-free, and pre-bonding basis, pores constitute at least 35 percent by volume of the microporous material, or at least 60 percent by volume of the

microporous material, or from 35 percent to 80 percent by volume of the microporous material, or from 60 percent to 75 percent by volume.

The particulate siliceous filler for use in the present invention can be selected from a wide variety that are known in the art. In a non-limiting embodiment, the particulate siliceous filler can be finely divided substantially water-insoluble siliceous particles. These particles can be in the form of ultimate particles, aggregates of ultimate particles, or a combination of both. In a non-limiting embodiment, at least 90 percent by weight of the siliceous particles used in preparing the microporous material can have gross particle sizes in the range of from about 5 to about 40 micrometers as determined by use of a Model TAII Coulter counter (Coulter Electronics, Inc.) but modified by stirring the filler for 10 minutes in Isoton II electrolyte (Curtin Matheson Scientific, Inc.) using a four-blade, 4.445 centimeter diameter propeller stirrer. In a further non-limiting embodiment, at least 90 percent by weight of the siliceous particles can have gross particle sizes in the range of from about 10 to about 30 micrometers. It is expected that the sizes of filler agglomerates can be reduced during processing of the ingredients to prepare the microporous material.

Non-limiting examples of suitable siliceous particles include, but are not limited to particles of silica, mica, montmorillonite, kaolinite, asbestos, talc, diatomaceous earth, vermiculite, natural and synthetic zeolites, cement, calcium silicate, aluminum silicate, sodium aluminum silicate, aluminum polysilicate, alumina silica gels, and glass particles. In a non-limiting embodiment, silica and/or the clay can be used as siliceous particles in the present invention. In a further non-limiting embodiment, precipitated silica, silica gel, or fumed silica can be used.

In alternate non-limiting embodiments, the finely divided particulate substantially water-insoluble siliceous filler can constitute from 50 to 90 percent by weight of the microporous material substrate, or from 50 to 85 percent by weight, or from 60 percent to 80 percent by weight.

In a non-limiting embodiment, the ink jet recordable substrate for use in the present invention can include non-siliceous filler particles. In a further non-limiting embodiment, finely divided substantially water-insoluble non-siliceous

filler particles can be used. Non-limiting examples of suitable non-siliceous filler particles can include but are not limited to particles of titanium oxide, iron oxide, copper oxide, zinc oxide, antimony oxide, zirconia, magnesia, alumina, molybdenum disulfide, zinc sulfide, barium sulfate, strontium sulfate, calcium carbonate, magnesium carbonate, magnesium hydroxide, and finely divided substantially water-insoluble flame retardant filler particles such as particles of ethylenebis(tetra-bromophthalimide), octabromodiphenyl oxide, decabromodiphenyl oxide, and ethylenebisdibromonorbornane dicarboximide.

A further description of suitable microporous materials for use in the present invention is provided in U.S. Patent Nos. 4,861,644 to Young et al. and 5,196,262 to Schwarz et al., the relevant portions of both are incorporated herein by reference.

A variety of suitable methods can be used to apply the coating composition to the ink recordable substrate. The coating compositions generally can be applied to the substrate using any conventional technique known in the art. Non-limiting examples of suitable methods include spraying, curtain coating, dipping, rod coating, blade coating, roller application, size press, printing, brushing, drawing, slot-die coating, and extrusion. In a non-limiting embodiment, the coating then can be formed by removing the solvent from the applied coating composition. Solvent removal can be accomplished by a wide variety of conventional drying techniques known in the art. In a non-limiting embodiment, the coating can be dried by exposing the coated substrate to forced air at a temperature in the range of from ambient to 350°F.

The coating composition can be applied once or a multiplicity of times. In a non-limiting embodiment, when the coating composition is applied a multiplicity of times, the applied coating usually can be dried, either partially or totally, between coating applications. In a further non-limiting embodiment, once the coating composition has been applied to the substrate, the solvent can be substantially removed, usually by drying.

In a non-limiting embodiment, an air knife coating technique wherein the coating composition is applied to the substrate and the excess is 'blown off' by a powerful jet from the air knife, can be used. In another embodiment, a reverse

roll coating can be used. In this procedure, the coating material can be measured onto an applicator roller by precision setting of the gap between an upper metering roller and the application roller below it. The coating can be 'wiped' off the application roller by the substrate as it passes around the support roller at the bottom.

In another embodiment of the present invention, gravure coating can be used to apply the coating composition. In the gravure coating method, an engraved roller can run in a coating bath, which fills the engraved dots or lines of the roller with the coating composition. Any excess coating on the roller can be wiped off by a doctor blade and the coating can be deposited onto the substrate as it passes between the engraved roller and a pressure roller. Reverse gravure coating methods can also be used. In this alternate method, the coating composition can be metered by the engraving on a roller before being wiped off as in a conventional reverse roll coating process.

In a further non-limiting embodiment, a metering rod can be used to apply the coating composition. When a metering rod is used, an excess of the coating can be deposited onto the substrate as it passes over a bath roller. The wire-wound metering rod, known as a Meyer Bar, allows the desired quantity of the coating to remain on the substrate. The quantity can be determined by the diameter of the wire used on the rod.

The thickness of the substantially dry coating can vary widely. In alternate non-limiting embodiments, the thickness of the coating can be in the range of from 1 to 40 microns, or from 5 to 25 microns, or from 5 to 15 microns.

The present invention is also directed to a coated microporous material substrate. In a non-limiting embodiment, the coated microporous substrate can include the microporous material substrate having at least one surface described above and which has a coating layer on at least one surface. The coating layer can be the dried coating composition of the present invention and can include an acrylic polymer, a polymeric nitrogen containing dye fixative compound and one or more polyurethanes as described above.

The amount of the substantially dry coating applied to the substrate, or coat weight, can be measured as coating weight per coated area. As used

herein and in the claims, "substantially dry" means that the coating layer feels dry to the touch. The amount of coating can vary widely. In alternate non-limiting embodiments, the amount of coating can be at least 0.001 gram per square meter, or at least 0.01 gram per square meter, or at least 0.1 gram per square meter. In alternate non-limiting embodiments, the amount of the coating can be 50 gram per square meter or less, or 40 gram per square meter or less, or 35 gram per square meter or less. The amount of the substantially dry coating applied to the substrate can vary between any of the afore-specified amounts.

The water-resistant ink jet recordable substrate of the present invention, can be polymer processed. In alternate non-limiting embodiments, the substrate can be laminated and/or molded. Lamination can be performed using a variety of techniques known to one having ordinary skill in the art. In a non-limiting embodiment, lamination can include bonding the ink jet recording substrate to at least one layer of a substantially nonporous material. The water-resistant ink jet recordable substrate can be bonded together with the substantially nonporous material in the presence or the absence of an adhesive. As used herein, "substantially nonporous" materials means those materials which are generally impervious to the passage of liquids, gases, and bacteria.

Substantially nonporous materials for use in the present invention can vary widely and can comprise those materials customarily recognized and employed for their known barrier properties. Non-limiting examples of such materials can include substantially nonporous thermoplastic polymers, substantially nonporous metalized thermoplastic polymers, substantially nonporous thermoset polymers, substantially nonporous elastomerics, and substantially nonporous metals. The substantially nonporous material can be in the form of a sheet, film, or foil, or other shapes can be used when desired, such as for example, plates, bars, rods, tubes, and forms of more complex shape. In one non-limiting embodiment, the substantially nonporous material for use in the present invention can be in the form or a sheet, film or foil.

As used herein and the claims, the term "thermoplastic polymer" means a polymer that can be softened by heat and then regain its original properties upon

cooling. The term "thermoset polymer" as used herein and the claims means a polymer that solidifies or sets on heating and cannot be remelted.

Non-limiting examples of thermoplastic polymeric materials which are suitable for use can include polyethylene, high density polyethylene, low density polyethylene, polypropylene, poly(vinyl chloride), saran, polystyrene, high impact polystyrene, nylons, polyesters such as poly(ethylene terephthalate), copolymers of ethylene and acrylic acid, copolymers of ethylene and methacrylic acid, and mixtures thereof. If desired, all or a portion of the carboxyl groups of carboxyl-containing copolymers can be neutralized with sodium, zinc, or the like. A non-limiting example of a metalized thermoplastic polymeric material can be aluminized poly(ethylene terephthalate).

Non-limiting examples of thermoset polymeric materials can include thermoset phenol-formaldehyde resin, thermoset melamine-formaldehyde resin, and mixtures thereof.

Non-limiting examples of elastomeric materials can include natural rubber, neoprene, styrene-butadiene rubber, acrylonitrile-butadiene-styrene rubber, elastomeric polyurethanes, and elastomeric copolymers of ethylene and propylene.

Non-limiting examples of metals can include but are not limited to iron, steel, copper, brass, bronze, chromium, zinc, die metal, aluminum, and cadmium.

In a non-limiting embodiment, a multilayer article comprising the present invention can be constructed using a wide variety of known methods for connecting at least one layer of an ink jet recordable substrate with at least one layer of a substantially nonporous material. In one non-limiting embodiment, at least one layer of a substantially water-resistant, at least partially coated ink jet recordable substrate can be fusion bonded to at least one layer of a substantially nonporous material. The ink jet recordable substrate generally comprises opposed major surfaces which are characteristic of sheets, films, foils, and plates. The resulting multilayer article can comprise one layer or more than one layer of the ink jet recordable substrate and one layer or more than one layer of the substantially nonporous material. In a non-limiting embodiment, at least one

exterior layer can be the ink jet recordable substrate. In an alternate non-limiting embodiment, the ink jet recordable substrate can be a microporous substrate.

In one non-limiting embodiment, the multilayer article of the present invention can be produced by fusion bonding in the absence of an adhesive. Fusion bonding can be accomplished using conventional techniques such as sealing through use of heated rollers, heated bars, heated plates, heated bands, heated wires, flame bonding, radio frequency (RF) sealing, and ultrasonic sealing. Solvent bonding can be used where the substantially nonporous substrate is at least partially soluble in the applied solvent to the extent that the surface becomes tacky. The ink jet recordable substrate can be contacted with the tacky surface, and the solvent then can be removed to form the fusion bond. In a non-limiting embodiment, foamable compositions can be foamed in contact with the ink jet recordable substrate to form a fusion bond between the foam and the substrate. Films or sheets of nonporous substrate can be extruded and while still hot and tacky, contacted with the ink jet recordable substrate to form a fusion bond. The fusion bond can be permanent or peelable, depending upon the known bonding technique and/or the nature of the substantially nonporous substrate employed.

In one non-limiting embodiment, heat sealing can be used to fusion bond an ink jet recordable substrate to a substantially nonporous material. In general, heat sealing includes inserting the ink jet recordable substrate into standard heat sealing equipment which is known in the art. In one non-limiting embodiment, the ink jet recordable substrate can be inserted in conjunction with the substantially nonporous material which can be a thermoplastic and/or thermoset polymer. Heat and/or pressure can be applied to the substrate/polymer construction for a period of time. The amount of heat and/or pressure and length of time can vary widely. In general, the temperature, pressure and time can be selected such that the substrate and polymer are at least partially connected together to form a multilayer article. In a non-limiting embodiment, the temperature can be within the range of from 100°F to 400°F. In another non-limiting embodiment, the pressure can be within the range of from 5 psi to 250 psi. In a further non-limiting embodiment, the period of time can be in the range

of from one (1) second to thirty (30) minutes. The multilayer article can then be cooled while under pressure for a typical period of time, such as thirty (30) minutes. Although the strength of the bond formed between the substrate and polymer can vary, in a non-limiting embodiment, the strength can be such that it generally exceeds the tensile properties of the substrate alone.

In one non-limiting embodiment, the substantially nonporous substrate can be polyvinyl chloride.

In another non-limiting embodiment, the ink jet recordable substrate employed in the present invention can be at least partially connected to a nonporous substrate such as polyethylene and polypropylene by heat sealing in the absence of an extrinsic adhesive. As used herein and the claims, the term "connected to" means to link together or place in relationship either directly, or indirectly by one or more intervening materials. The resultant fusion bond can be sufficiently strong which is surprising inasmuch as the lamination of materials to polyolefins can be difficult unless adhesives are used.

In alternate non-limiting embodiments, the ink jet recordable substrate can be substantially continuously at least partially connected to the substantially nonporous substrate, or it can be discontinuously at least partially connected to the substantially nonporous substrate. Non-limiting examples of discontinuous bonds can include bonding areas in the form of one or more spots, patches, strips, stripes, chevrons, undulating stripes, zigzag stripes, open-curved stripes, closed-curved stripes, irregular areas, and the like. In a further non-limiting embodiment, when patterns of bonds are involved, they can be random, repetitive, or a combination of both.

In another non-limiting embodiment, an ink jet recordable substrate can be connected to a substantially nonporous material in the presence of an adhesive. The adhesive for use in the present invention can be selected from a wide variety of adhesives known in the art. Non-limiting examples of suitable adhesives include those having a sufficient molecular weight and viscosity such that the adhesive will not substantially migrate into or substantially penetrate the ink jet recordable substrate. Migration or penetration of the adhesive into the substrate can reduce the tack and bond strength of the adhesive. Non-limiting

examples of suitable adhesives for use in the present invention can include but are not limited to polyvinyl acetate, starches, gums, polyvinyl alcohol, animal glues, acrylics, epoxies, polyethylene-containing adhesives, and rubber-containing adhesives. In alternate non-limiting embodiments, the adhesive can be applied to the substrate, or to the substantially nonporous material, or to both the substrate and the substantially nonporous material. In a further non-limiting embodiment, the adhesive can be introduced via the use of a tie carrier coating.

The process of bonding the substrate and substantially nonporous material in the presence of an adhesive generally includes inserting the substrate/adhesive/material construction into standard processing equipment which is known in the art. Heat and/or pressure can be applied to the substrate/adhesive/material construction for a period of time. The amount of heat and/or pressure and length of time can vary widely. In general, the temperature, pressure and time are selected such that the substrate and substantially nonporous material are at least partially connected together to form a multi-layer article. A typical temperature can be within the range of from 100°F to 400°F. A typical pressure can be within the range of from 5 psi to 250 psi, and a typical period of time can be in the range of from one (1) second to thirty (30) minutes. The multilayer article may then be cooled under pressure for a typical time period, such as thirty (30) minutes. Although the strength of the bond formed between the ink jet recordable substrate and the substantially nonporous material can vary, the bond generally can be such that it typically exceeds the tensile properties of the substrate alone.

In one non-limiting embodiment of the present invention, an ink jet recordable substrate can be molded using a variety of conventional molding techniques known in the art, which can include but are not limited to compression molding, rotational molding, injection molding, calendaring, roll/nip laminating, thermoforming vacuum forming, extrusion coating, continuous belt laminating and extrusion laminating.

In alternate non-limiting embodiments, the substrate can be molded in the presence or the absence of a substantially nonporous material, such as a thermoplastic and/or thermoset polymer. In general, the ink jet recordable

substrate is inserted into standard molding equipment which is known in the art. In one non-limiting embodiment, a thermoplastic and/or thermoset polymer is introduced onto the substrate and then the substrate/polymer construction is inserted into the mold cavity. In another one non-limiting embodiment, the substrate is placed into the mold cavity and then the thermoplastic and/or thermoset polymer is introduced onto the substrate. Heat and/or pressure can be applied to the substrate/polymer construction for a period of time. The amount of heat and/or pressure and length of time can vary widely. In general, the temperature, pressure and time are selected such that the substrate and polymer are at least partially connected together to form a multi-layer article. A typical temperature can be within the range of from 100°F to 400°F. In a non-limiting embodiment, wherein the polymer comprises a thermoplastic polymer, the substrate/polymer construction can be heated to a temperature that equals or exceeds the melt temperature of the thermoplastic polymer. In one non-limiting embodiment, where the thermoplastic polymer can be amorphous, the substrate polymer construction can be heated to a temperature that equals or exceeds the Vicat temperature. In an alternative non-limiting embodiment, wherein the polymer comprises a thermoset polymer, the temperature can be below the curing or crosslinking temperature of the polymer. A typical pressure can be within the range of from 5 psi to 250 psi, and a typical period of time can be in the range of from one (1) second to fifteen (15) minutes. The result of a typical molding process is a re-shaping of the original article. The re-shaping is generally defined by the design of the mold cavity. Thus, in a standard molding process, a two-dimensional flat sheet can be re-shaped into a three-dimensional article.

In one non-limiting embodiment of the present invention, the ink jet recordable substrate comprises Teslin which is available from PPG Industries, Incorporated in Pittsburgh, PA. The thickness of the ink jet recordable substrate of the present invention varies widely depending on the application for use. In one non-limiting embodiment, the ink jet recordable substrate can be from 5 to 20 mils thick.

In one non-limiting embodiment, other tie coatings known in the art can be used in conjunction with the substrate and the substantially nonporous material.

In a non-limiting embodiment, a friction-reducing coating composition can be at least partially applied to at least one of the ink jet recordable substrate and the substantially nonporous material. In a further non-limiting embodiment, the friction-reducing coating composition can comprise at least one lubricant and at least one resin. There are a wide variety of lubricants and resins known to the skilled artisan that could be useful herein. Non-limiting examples of such suitable lubricants can include natural and synthetic waxes, natural and synthetic oils, polypropylene waxes, polyethylene waxes, silicone oils and waxes, polyesters, polysiloxanes, hydrocarbon waxes, carnauba waxes, microcrystalline waxes and fatty acids, and mixtures thereof. In a non-limiting embodiment, the lubricant for use in the present invention can include polysiloxanes, such as but not limited to silicone.

Non-limiting examples of suitable resins can include polyurethanes, polyesters, polyvinyl acetates, polyvinyl alcohols, epoxies, polyamides, polyamines, polyalkylenes, polypropylenes, polyethylenes, polyacrylics, polyacrylates, polyalkylene oxides, polyvinyl pyrrolidones, polyethers, polyketones, and co-polymers and mixtures thereof. In a non-limiting embodiment, the resin for use in the present invention can include styrene acrylic polymers such as but not limited to styrene acrylic-comprising polyurethanes, polyepoxies, polyvinyl alcohols, polyesters, polyethers, and co-polymers and mixtures thereof.

In a further non-limiting embodiment, the friction-reducing coating composition for use in the present invention can include Wikoff SCW 4890 and 2295 which are commercially available from Wikoff Industries, Incorporated, as poly board aqua coat products.

Not intending to be bound by any particular theory, it is believed that the molecules of the resin component of the friction-reducing coating can be at least partially interconnected or interlinked with the ink jet recordable substrate and/or the substantially nonporous material, such that the silicone can be essentially fixed to the surface of said substrate and/or said material. In a non-limiting

embodiment, the molecules of a thermoplastic resin component can be interconnected by fusion to the ink jet recordable substrate and/or the substantially nonporous material. In another non-limiting embodiment, the molecules of a thermoset resin component can be interlinked by crosslinking to the ink jet recordable substrate and/or the substantially nonporous material.

In a further non-limiting embodiment, the friction-reducing coating composition can comprise water and/or an organic solvent. A wide variety of organic solvents known to the skilled artisan can be useful herein. Non-limiting examples of such suitable organic solvents can include but are not limited to N-methyl pyrrolidone (NMP), methyl ethyl ketone (MEK), acetone, diethyl ether, toluene, Dowanol PM, Butyl Cellosolve, and mixtures thereof. In a non-limiting embodiment, the friction-reducing coating composition can comprise water and an organic solvent, wherein said organic solvent is at least partially miscible with water.

In a non-limiting embodiment, the friction-reducing coating composition can be at least partially applied to at least one of the ink jet recordable substrate and the substantially nonporous material of the present invention. Application of said friction-reducing coating composition to said substrate and/or said material can employ a wide variety of known techniques. In alternate non-limiting embodiments, the techniques described previously herein for applying the substantially water-resistant coating to the ink jet recordable substrate can be used for application of the friction-reducing coating composition to the ink jet recordable substrate and/or the substantially nonporous material.

The amount of the substantially dry friction-reducing coating applied to the substrate/material, or "coat weight", is typically measured as coating weight per coated area. The coat weight can vary widely. In alternate non-limiting embodiments, the coat weight of the substantially dry friction-reducing coating can be at least 0.1 gram per square meter, or from greater than 0 to 50 grams per square meter, or from 1 gram per square meter to 15 grams per square meter.

In a non-limiting embodiment, the multilayer article of the present invention can include a 10 mil thick sheet of Teslin comprising a substantially

water-resistant coating composition, a 10 mil sheet of polyvinylchloride, a 10 mil thick sheet of polyvinylchloride, and a 2 mil thick sheet of polyvinylchloride comprising a friction-reducing coating composition. In a further non-limiting embodiment, the friction-reducing coating composition can comprise a polysiloxane and a styrene acrylic polymer.

In a non-limiting embodiment, the multilayer article of the present invention can include a magnetizable material. As used herein and the claims, the term "magnetizable material" means a material to which magnetic properties can be communicated. A wide variety of magnetizable materials are known to one skilled in the art. Known magnetizable materials are available in various forms such as but not limited to sheet, film, tape or stripe.

Magnetizable materials for use in the present invention can be selected from a variety of materials capable of being magnetized by a magnetic field. Suitable magnetizable materials can include but are not limited to oxide materials. Non-limiting examples of suitable oxide materials can include ferrous oxide, iron oxide, and mixtures thereof. In a non-limiting embodiment, the oxide particles can be present in a slurry formulation.

Suitable magnetizable materials for use in the present invention can include those known in the art which demonstrate performance characteristics such as but not limited to the ability to be encoded with sufficient ease, ability to encode a sufficient amount of information, and ability to be erased with sufficient resistance. In a non-limiting embodiment, the amount of information encoded onto the magnetizable material can be referred to as the number of stages or tracks. The number of stages or tracks can vary. In alternate non-limiting embodiments, the magnetizable material for use in the present invention can have at least one (1) track, or not more than six (6) tracks, or from three (3) to four (4) tracks.

In a non-limiting embodiment, the resistance to erasure can be referred to as "coercivity". In general, the higher the coercivity value, the greater the resistance to erasure. The coercivity value can vary. In alternate non-limiting embodiments, the magnetizable material for use in the present invention can

have a coercivity of at least 200, or not more than 5000, or from 500 to 2500, or from 100 to 1500.

Non-limiting examples of suitable magnetizable materials for use in the present invention can include but are not limited to magnetic foils which are commercially available from JCP, Kurz, EMTEC and DuPont.

In a non-limiting embodiment, the magnetizable material can be at least partially connected to at least one or more materials selected from a protective material, a carrier material or an adhesive material. The protective material, carrier material and adhesive material can be selected from a wide variety of materials known in the art as useful for each function. Non-limiting examples of suitable protective materials can include but are not limited to PET (polyethylene terapthalate), polyester and combinations thereof. Non-limiting examples of carrier materials can include but are not limited to PET, polyester and combinations thereof. Non-limiting examples of suitable adhesive materials can include but are not limited to those recited herein.

In another non-limiting embodiment, the protective material can be at least partially connected to the magnetizable material, the magnetizable material can be at least partially connected to the carrier material, and the carrier material can be at least partially connected to the adhesive material.

In alternate non-limiting embodiments, the magnetizable material can be at least partially connected to an ink jet recordable substrate and/or at least one substantially nonporous material. Non-limiting examples of ink jet recordable substrates can include but are not limited to those previously recited herein. In a non-limiting embodiment, the ink jet recordable substrate can be a microporous substrate such as those previously recited herein. In a further non-limiting embodiment, the microporous substrate can be Teslin® printing sheet which is commercially available from PPG Industries, Incorporated. Non-limiting examples of suitable substantially nonporous materials can include but are not limited to those previously recited herein. In a non-limiting embodiment, the substantially nonporous material can be polyvinyl chloride.

The magnetizable material-containing multilayer article of the present invention can be prepared by various methods known in the art. In a non-limiting

embodiment, the magnetizable material can be at least partially connected to at least one substantially nonporous material. Various application techniques suitable for at least partially connecting the magnetizable material to the substantially nonporous material are known to a skilled artisan. In a non-limiting embodiment, the magnetizable material can be at least partially connected using an adhesive material. Non-limiting examples of suitable adhesive materials can include but are not limited to a wide variety of adhesives known to the skilled artisan, such as but not limited to those previously recited herein. In a non-limiting embodiment, the adhesive material can be selected from thermal- or pressure-sensitive adhesives.

In a further non-limiting embodiment, the magnetizable material can be at least partially connected to the adhesive material, and the adhesive material can be at least partially connected to a surface of the microporous substrate and/or at least one substantially nonporous material.

In alternate non-limiting embodiments, the magnetizable material can be at least partially connected to a microporous substrate and/or at least one substantially nonporous material prior to, during, or following a conventional lamination process such as but not limited to the lamination process previously described herein.

In another non-limiting embodiment, the magnetizable material can be essentially flush with the surface of the microporous substrate and/or substantially nonporous material to which it can be connected.

In a non-limiting embodiment, a substantially water-resistant coating composition can be at least partially applied to the magnetizable material. In alternate non-limiting embodiments, the coating can be at least partially applied to the magnetizable material either prior to or following at least partially connecting the magnetizable material to a microporous substrate or a substantially nonporous material. In a further non-limiting embodiment, an adhesive material can be at least partially applied to the uncoated surface of the magnetizable material, and the adhesive-containing surface can be at least partially connected to the microporous substrate or substantially nonporous material. In alternate non-limiting embodiments, the substantially water-resistant

coating composition can be at least partially applied to at least one of the magnetizable material, the microporous substrate and the substantially nonporous material. In still a further non-limiting embodiment, the substantially water-resistant coating composition can include that which is recited herein.

In a non-limiting embodiment, a friction reducing coating composition can be at least partially applied to the magnetizable material. In alternate non-limiting embodiments, the coating can be at least partially applied to the magnetizable material either prior to or following at least partially connecting the magnetizable material to a micorporous substrate or a substantially nonporous material. In a further non-limiting embodiment, an adhesive material can be at least partially applied to the uncoated surface of the magnetizable material, and the adhesive-containing surface can be at least partially connected to the microporous substrate or substantially nonporous material. In alternate non-limiting embodiments, the friction reducing coating composition can be at least partially applied to at least one of the magnetizable material, the microporous substrate, and substantially nonporous material. In still a further non-limiting embodiment, the substantially friction reducing coating composition can include that which is recited herein.

The coating compositions can be applied by a variety of methods known in the art. In alternate non-limiting embodiments, the coating compositions can be applied by the methods previously described herein.

In a further non-limiting embodiment, a multilayer article of the present invention can include a microporous substrate at least partially connected to a first substantially nonporous material; the first substantially nonporous material can be at least partially connected to a second substantially nonporous material; the second substantially nonporous material can be at least partially connected to a third substantially nonporous material; said third substantially nonporous material can include a magnetizable material. In a further non-limiting embodiment, the microporous substrate and/or substantially nonporous materials can be at least partially connected using an adhesive material which can be at least partially applied to at least one surface of the substrate and/or materials.

coating composition can be at least partially applied to at least one of the magnetizable material, the microporous substrate and the substantially nonporous material. In still a further non-limiting embodiment, the substantially water-resistant coating composition can include that which is recited herein.

In a non-limiting embodiment, a friction reducing coating composition can be at least partially applied to the magnetizable material. In alternate non-limiting embodiments, the coating can be at least partially applied to the magnetizable material either prior to or following at least partially connecting the magnetizable material to a micorporous substrate or a substantially nonporous material. In a further non-limiting embodiment, an adhesive material can be at least partially applied to the uncoated surface of the magnetizable material, and the adhesive-containing surface can be at least partially connected to the microporous substrate or substantially nonporous material. In alternate non-limiting embodiments, the friction reducing coating composition can be at least partially applied to at least one of the magnetizable material, the microporous substrate, and substantially nonporous material. In still a further non-limiting embodiment, the substantially friction reducing coating composition can include that which is recited herein.

The coating compositions can be applied by a variety of methods known in the art. In alternate non-limiting embodiments, the coating compositions can be applied by the methods previously described herein.

In a further non-limiting embodiment, a multilayer article of the present invention can include a microporous substrate at least partially connected to a first substantially nonporous material; the first substantially nonporous material can be at least partially connected to a second substantially nonporous material; the second substantially nonporous material can be at least partially connected to a third substantially nonporous material; said third substantially nonporous material can include a magnetizable material. In a further non-limiting embodiment, the microporous substrate and/or substantially nonporous materials can be at least partially connected using an adhesive material which can be at least partially applied to at least one surface of the substrate and/or materials.

In another non-limiting embodiment, a release liner can be at least partially connected to at least one surface of the multilayer article of the present invention. The release liner can function as a barrier to essentially prevent or minimize damage of the article during the manufacture process. In a non-limiting embodiment, a coating residue can be deposited on the stainless steel equipment during the lamination process as a result of print-off. Deposition of the coating on the equipment can result in at least partial damage to the coated surface of the multilayer article. In alternate non-limiting embodiments, a release liner can be at least partially connected to a coated or uncoated magnetizable material, a coated or uncoated substantially nonporous material, and/or a coated or uncoated microporous substrate.

The release liner can be selected from a wide variety of materials known in the art to perform the above-stated function. In general, a material suitable for use as a release liner in the present invention can have at least one of the following characteristics: a melt temperature in excess of the lamination temperature, the ability to essentially not migrate into the material and an acceptable tear strength such that it can be pulled away with sufficient ease.

In a further non-limiting embodiment, the microporous substrate, the substantially non-porous material, and magnetizable-containing substantially non-porous material can be aligned in an essentially parallel configuration to form a stacked article.

In another non-limiting embodiment, the microporous substrate can be at least partially connected to the substantially nonporous material in the absence of an adhesive material. In another non-limiting embodiment, the substantially nonporous material can be at least partially connected to another substantially nonporous material in the absence of an adhesive material.

In another non-limiting embodiment, the multilayer article of the present invention can include a data transmittance/storage device. Such devices can vary widely. Suitable devices for use in the present invention can include those known in the art. In a non-limiting embodiment, the device can include an antenna, electronic chip and/or other related circuitry. In a further embodiment, the device can include a carrier material. The carrier material can be selected

from a wide variety of materials known in the art. In a non-limiting embodiment, the carrier material can be a substantially nonporous material. Suitable substantially nonporous materials can include those previously recited herein. In a non-limiting embodiment, the carrier material can be polyvinylchloride.

In still a further embodiment, the device can include a barrier material on at least one side of the circuitry. A function of the barrier material can be to encompass the circuitry and provide a substantially flat surface on the outside of the device. The barrier material can be selected from a wide variety of materials known in the art. In a non-limiting embodiment, the barrier material can be a substantially nonporous material. Suitable substantially nonporous materials can include those previously recited herein. In a non-limiting embodiment, the barrier material can be polyvinylchloride.

In a non-limiting embodiment, the multilayer article of the present invention can include an ink jet recordable substrate, a data transmittance/storage device, and at least one substantially nonporous material. The ink jet recordable substrate can be selected from a wide variety of such materials known in the art. Suitable non-limiting examples can include those previously described herein. In a non-limiting embodiment, the ink jet recordable substrate can be a microporous substrate such as those previously recited herein. In a further non-limiting embodiment, the ink jet recordable substrate can be Teslin® printing sheet which is commercially available from PPG Industries, Incorporated. As previously described herein, the ink jet recordable substrate can be at least partially coated on at least one surface or uncoated. Suitable coating compositions can include those previously described herein. In a non-limiting embodiment, a substantially water-resistant coating composition can be at least partially applied to the ink jet recordable substrate.

The substantially nonporous material can be selected from a wide variety of such materials known in the art. Suitable non-limiting examples of substantially nonporous materials can include those previously described herein. In a non-limiting embodiment, the substantially nonporous material can be polyvinylchloride. As previously described herein, the substantially nonporous material can be at least partially coated on at least one surface or uncoated.

Suitable coating compositions can include those previously described herein. In a non-limiting embodiment, a friction-reducing coating composition can be at least partially applied to the substantially nonporous material.

In a further non-limiting embodiment, the data transmittance/storage device can be at least partially connected to the barrier material using an adhesive material. A wide variety of suitable adhesive materials and methods of application are known in the art. Non-limiting examples include those adhesive materials and methods of application previously described herein.

In another non-limiting embodiment, the barrier material can have at least one surface at least partially coated with a coating composition. Suitable coating compositions can include those previously described herein. In a non-limiting embodiment, a friction-reducing coating composition can be at least partially applied to the barrier material.

In a non-limiting embodiment, the multilayer article with magnetizable material or with a transmittance/storage device, can have a thickness that varies widely. In alternate non-limiting embodiments, the thickness of the article can be at least 10 mils, or less than 60 mils, or from 30 to 50 mils.

The multilayer article with magnetizable material or with a data transmittance/storage device can be useful in a wide variety of applications. In alternate non-limiting embodiments, it can be used in applications related to security access, access-control, data storage and data transmittance.

The multilayer article of the present invention has many and varied uses including gaskets, cushion assemblies, signs, cards, printing substrates, substrates for pen and ink drawings, maps (particularly maritime maps), book covers, book pages, wall coverings, and seams, joints, and seals of breathable packages.

The multilayer article of the present invention can be useful for the purpose of decorating or identifying the substantially nonporous material, or imparting to the substantially nonporous material unique properties of the substrate surface. The ink jet recordable substrate can be decorated with a variety of methods including: offset/lithographic printing, flexographic printing, painting, gravure printing, inkjet printing, electrophotographic printing,

sublimation printing, thermal transfer printing, and screen printing. Decorating can also include applying a single or multilayer coating to the ink jet recordable substrate via normal coating methods known in the art. In general, the unique properties that an ink jet recordable substrate can impart on a substantially nonporous material include, but are not limited to one or more of: improved surface energy, increased porosity, decreased porosity, increased bond strength of post coat layer, and modification of the polymer's surface texture or pattern.

Polymer processing techniques are disclosed in U.S. Patent No. 4,892,779, which is incorporated herein by reference.

The present invention is more particularly described in the following examples, which are intended to be illustrative only, since numerous modifications and variations therein will be apparent to those skilled in the art. Unless otherwise specified, all parts and percentages are by weight and all references to water are meant to be deionized water.

In the following examples, the term "Teslin" refers to Teslin TS 1000, unless otherwise stated.

EXAMPLES

Example 1

In preparing a coating composition of the present invention, a 31% polydimethyldiallylammonium chloride sold under the trade name CinFix RDF available from Stockhausen GmbH & Co. KG, Krefeld, Germany was diluted to 10% with deionized water in a stainless steel or polyethylene mix vessel under mild agitation. Mild agitation defined by a medium pitch three lobed mixing head, the system at a mix-head to mix vessel diameter ratio of 1 to 3 and the mix-head spinning at 600 – 1000 rpm and appropriately positioned. In a separate mix container, a 29% aqueous cationic acrylic solution sold under the name WC-71-2143 available from PPG Industries, Inc. is diluted with deionized water to 10% and added to the main mix vessel containing pre diluted CinFix RDF. In a separate mix container, a 30% aqueous cationic polyurethane dispersion sold under the trade name Witcobond W240 available from Crompton Corporation is

diluted with deionized water to 10% and added to the main mix vessel containing the CinFix RDF and PPG WC-71-2143 mixture. The resultant coating composition is stirred for 15 minutes. The resultant pH was 5.5 +/- 0.5. The total solids of the composition was 10% and a viscosity of 56cps measured using a Brookfield viscometer, RVT, spindle no. 1, at 50 rpm and 25°C.

For comparison with 8181-67-09, other coating compositions were produced using alternate CinFix additives and polyurethane dispersions with or without WC-71-2143.

Ingredients	% solids	8181-67-01	-02	-03	-04	-05	-06	-07	-08	-09
CinFix NF	51	18.5	-	-	-	-	-	-	-	-
CinFix 167	10	-	100	100	100	100	-	-	-	-
CinFix RDF	10	-	-	-	-	-	100	100	100	100
WitcoBond W-234	31	49.6	-	-	-	-	-	-	-	-
WitcoBond X-051	10	-	150	75	-	-	150	75	-	-
WitcoBond W-240	10	-	-	-	150	75	-	-	150	75
WC-71-2143	10	-	-	75	-	75	-	75	-	75

All values are in parts by weight (pbw).

Ingredients:

CinFix NF – a 50-60% active aqueous solution of poly(quaternary amine) polymer (CAS No. 68583-79-9) from Stockhausen GmbH & Co. KG, Krefeld, Germany

CinFix 167 – a 50-60% active aqueous solution of poly(quaternary amine) (Composition -Trade Secret) from Stockhausen GmbH & Co. KG, Krefeld, Germany

CinFix RDF – a 30-35% active aqueous solution of poly(quaternary amine) polymer (CAS No. 26062-79-3) from Stockhausen GmbH & Co. KG, Krefeld, Germany

WitcoBond W-234 – a 30-35% solids water-based dispersion of an anionic aliphatic urethane from Uniroyal Chemical of Middlebury, CT.

WitcoBond X-051 – a 30-35% solids water-based dispersion of a cationic urethane from Uniroyal Chemical of Middlebury, CT

WitcoBond W-240 – a 30-35% solids water-based self-cross linking anionic polyurethane dispersion from Uniroyal Chemical of Middlebury, CT

WC-71-2143 – a 25-30% solids aqueous dispersion of a cationic acrylic polymer from PPG Industries of Pittsburgh, PA.

PPG formulation no. WC-71-2143 is as an aqueous secondary amine and hydroxyl functional acrylic polymer prepared via solution polymerization. Also described as a cationic acrylic polymer aqueous dispersion. WC-71-2143 was prepared as follows.

Table 1

Ingredients	Weight, grams
Initial Charge	
Isopropanol	130.0
Feed 1	
Isopropanol	113.0
n-Butyl acrylate	69.2
Methyl methacrylate	153.0
2-(tert-Butylamino)ethyl methyacrylate (CAS 3775-90-4)	73.0
Styrene	69.2
VAZO® 67 Initiator[1]	18.2
Feed 2	
Glacial Acetic Acid	17.7
Feed 3	
Deionized Water	1,085.0

[1] 2, 2'-Azobis(2-methylbutanenitrile) initiator commercially available from E. I. du Pont de Nemours and Company, Wilmington, Delaware

The initial charge was heated in a reactor with agitation to reflux temperature (80°C.). The Feed 1 was added in a continuous manner over a period of 3 hours. At the completion of Feed 1 addition, the reaction mixture was held at reflux for 3 hours. The resultant acrylic polymer solution had a total solids

content of 61.7 percent (determined by weight difference of a sample before and after heating at 110°C. for one hour) and number average molecular weight of 4792 as determined by gel permeation chromatography using polystyrene as the standard. Thereafter, Feed 2 was added over five minutes at room temperature with agitation. After the completion of the addition of Feed 2, Feed 3 was added over 30 minutes while the reaction mixture was heated for azeotropic distillation of isopropanol. When the distillation temperature reached 99°C, the distillation was continued about one more hour and then the reaction mixture was cooled to room temperature. The total distillation collected was 550.6 grams. The product, which was a cationic acrylic polymer aqueous solution, had a solids content of 32.6 percent by weight (determined by weight difference of a sample before and after heating at 110°C. for one hour), and a pH of 5.25.

Note: All % solids values are % by weight.
Coatings were applied to blank 8½" x 11" Teslin® TS 1000 sheet. Coating weight is measured by difference using an electronic balance.

- The blank sheet is weighed.
- Coating is applied to the front side using a #9 wire-wrapped rod.
- The sheet is baked at 95° C in a textile oven (Model LTF from Werner Mathis AG, Zurich, Switzerland) for 2 minutes.
- The sheet is removed from the oven and coating is applied to the backside using a #9 wire-wrapped rod.
- The sheet is re-baked at 95° C in the textile oven for 2 minutes.
- The sheet is removed, allowed to cool to the touch and reweighed.
- Coating weight in milligrams/square-inch is determined by dividing weight difference in milligrams by coated area.

The dynamic viscosity of the mixed coatings was measured using a #2 Zahn cup and the static viscosity was measured using a Brookfield Model DV-1+ viscometer using a #2 spindle at 100 rpm.

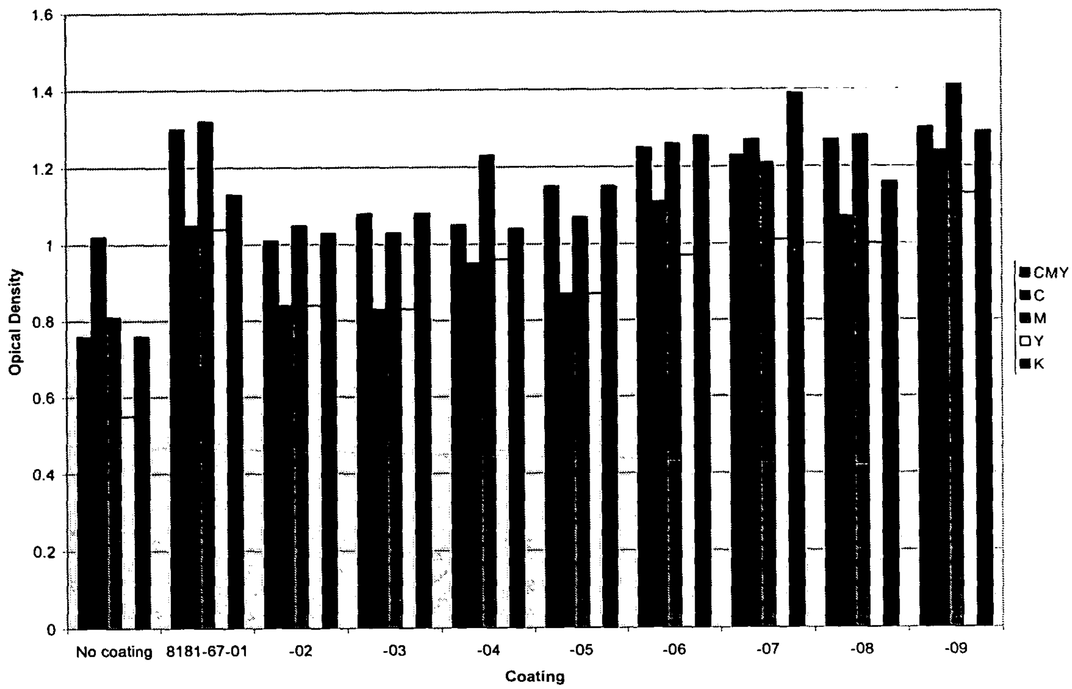
Coating 8181-	Coating	#2 Zahn	Brookfield

67-	Weight mg./square inch	cup (seconds)	Viscosity (Centipoise @ 22°C)
-01	2.5	16.5	51.6
-02	0.4	23.6	236.4
-03	0.9	17.7	65.6
-04	1.5	15.5	40
-05	0.3	21.1	85.6
-06	0.4	21.7	125.2
-07	0.9	16.1	40.8
-08	0.6	16.3	48.8
-09	1.1	15.4	41.2

Test prints from the coated Teslin sheets were generated off of an HP960C printer, set to normal default print mode. Optical density values were measured using an X-Rite® densitometer, model type 418, normalized against a Macbeth® black/white standard plate. Test prints were also generated using uncoated Teslin TS1000 for comparison. Optical density values are listed in the following table.

Coating	CMY	C	M	Y	K
No coating	0.76	1.02	0.81	0.55	0.76
8181-67-01	1.30	1.05	1.32	1.04	1.13
-02	1.01	0.84	1.05	0.84	1.03
-03	1.08	0.83	1.03	0.83	1.08
-04	1.05	0.95	1.23	0.96	1.04
-05	1.15	0.87	1.07	0.87	1.15
-06	1.25	1.11	1.26	0.97	1.28
-07	1.23	1.27	1.21	1.01	1.39
-08	1.27	1.07	1.28	1.00	1.16
-09	1.30	1.24	1.41	1.13	1.29

Coating 8181-67-09 is clearly the best overall in optical density performance of all the examples as is illustrated in the following graphic representation of the previous Table. The use of WC-71-2143 in the formula provides improved optical density over polyurethane dispersion-only formulas.



Coating 8181-67-09 was applied to 8½" x 11" sheets of Teslin® TS1000 and SP1000 and cured as described above. Test prints from the coated Teslin sheets were generated off of an HP960C printer, set to normal default print mode. Optical density values were measured using an X-Rite® densitometer, model type 418, normalized against a Macbeth® black/white standard plate. Optical density values are listed in the following table.

Teslin	CMY	C	M	Y	K
TS1000	1.08	1.20	1.23	0.99	1.16
SP1000	1.09	1.22	1.22	1.02	1.16

Example 2

Coating composition prepared as in example 1 and was applied to a 500ft roll of 10.5mil Teslin TS1000 microporous substrate by a flexographic or gravure coating method. In this coating method, a line consisting of two coating stations, each with a forced air drying oven was used. Each coating station consists of a coating feed chamber, anilox roll and rubber application roll. The coating feed chambers were supplied from a coating holding tank and pump. Continuous roll

stock was threaded through the equipment so that both side were coated during a single pass. The apparatus was fitted with a 7BCM (billion cubic microns) roll and a 5BCM anilox roll. Successive passes were arranged so that both sheet surfaces contacted the rubber roll wet by each anilox roll type at least once. The complete coating sequence is described as follows: Pass #1 (7bcm-face/5bcm-back) + Pass #2 (7bcm-face/5bcm-back) + Pass # 3 (5bcm-face/7bcm-back). The line speed was 240fpm, oven temperature was 105°C (220°F) and 3 passes per roll were made, which translates into 3 passes per surface. The coating composition was applied with an approximate coat weight of 0.73g/m^2 (total front and back). The resultant roll was converted into 8.5" x 11"sheets, grain long. Test prints were generated off of an HP960C printer, set to normal default print mode. Both sides of the substrate were printed. Optical density values were measured using an X-Rite® densitometer, model type 418, normalized against a Macbeth® black/white standard plate. Optical densities values are listed in the following table.

Optical Density Values

Sheet Surface	CMY	C	M	Y	K
Side A	1.39	1.06	1.10	0.77	1.44
Side B	1.36	1.04	1.10	0.75	1.50

In addition to optical density the prints had good overall aesthetics, distinctness of image and quality.

Example 3

Two 6,600ft rolls of 10.5mil Teslin TS1000 were sized with coating composition described in example 1 in the same manner as described in example 2. The resultant rolls was converted into 8.5" x 11"sheets, grain long. Test prints were generated off of an HP960C printer set to normal default print mode and best ink jet photo grade matte finish. Both sides of the substrate were printed. Optical density values were measured using an X-Rite® densitometer, model type 418, normalized against a Macbeth® black/white standard plate. Optical densities values are listed in the following table.

Optical Density Values

Sheet Surface	Print Setting	CMY	C	M	Y	K
Side A	Normal Default	1.47	1.07	1.26	0.86	1.65
Side B	Normal Default	1.54	1.09	1.30	0.88	1.65
Side A	Best, Ink Jet Photo Grade Matte Finish	1.32	1.12	1.27	0.86	1.20
Side B	Best, Ink Jet Photo Grade Matte Finish	1.29	1.11	1.25	0.89	1.16

In addition to the optical density values, the prints generated using best mode had better image quality compared to normal mode prints. These same images printed using best mode had very good pigmented ink adhesion as measured using a coin rub test. The printed surface was rubbed with a coin until the substrate began to fatigue and fail. The printed surface maintained an acceptable distinctness of image with very little ink rub off.

Example 4

A treated sheet (sample A) from the substrate prepared in the previous example was printed with a test print pattern; using printer type HP960c set on best mode, ink jet photo grade matte finish. The optical density of color bars representing the five primary color/ink types: composite black, cyan, magenta, yellow and pigment black were measured. The printed color bars were submerged in de-ionized water for 24 hours and the resultant optical densities measured. The procedure was then repeated after a total of 96 hours of continuous soaking. The test was repeated on two additional samples (B & C) from the same lot of substrate and both printed in the same manner. The optical density values are given in the following tables.

Optical Density Retention (Sample A)

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.37	1.32	1.22	0.90	1.36
24 hours	1.31	1.31	1.23	0.90	1.35
96 hours	1.35	1.31	1.26	0.89	1.34

Optical Density Retention (Sample B)

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.33	1.25	1.27	0.92	1.32
24 hours	1.25	1.31	1.35	0.98	1.22
96 hours	1.25	1.30	1.37	0.99	1.20

Optical Density Retention (Sample C)

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.39	1.33	1.22	0.91	1.37
24 hours	1.39	1.35	1.29	0.92	1.37
96 hours	1.39	1.32	1.31	0.92	1.36

All color bars remained solid after 96hours of soaking time. Also only some slight bleed was visible off of the composite and pigment black color bars. Bold 10point font that was part of the test print samples remained legible.

Example 5

Several 6,600ft rolls of 10.5mil Teslin TS1000 were sized with coating composition described in example 1 in accordance the technique described in example 2. The resultant rolls was converted into 8.5" x 11"sheets, grain long. Test prints were generated off of an HP960C printer, set to best ink jet photo grade matte finish. Both sides of the substrate were printed. The optical density of color bars representing the five primary color/ink types: composite black, cyan, magenta, yellow and pigment black were measured. The printed color bars were submerged in tap water for 15minutes and the resultant optical densities measured. The procedure was then repeated after a total of 24hours of continuous soaking. The optical density values are given in the following tables.

Optical Density Retention – Side A
24hrs, Tap Water

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.31	1.13	1.26	0.88	1.30
15 minutes	1.31	1.14	1.25	0.90	1.30
24 hours	1.32	1.12	1.24	0.89	1.29

Optical Density Retention – Side B
24hrs, Tap Water

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.31	1.14	1.27	0.89	1.30
15 minutes	1.33	1.14	1.23	0.91	1.30
24 hours	1.29	1.10	1.23	0.90	1.29

All color bars remained solid after 24hours of soaking time in tap water. No bleed was visible off of any of the colors. Bold 10point font that was part of the test print samples, printed in composite black maintained good optical clarity.

Example 6

Samples collected after two coating passes during the campaign described in the previous example were converted into 8.5" x 11" sheets, grain long and tested. Test prints were generated off of an HP960C printer, set to best ink jet photo grade matte finish. Both sides of the substrate were printed. The optical density of color bars representing the five primary color/ink types: composite black, cyan, magenta, yellow and pigment black were measured. The printed color bars were submerged in tap water for 15minutes and the resultant optical densities measured. The procedure was then repeated after a total of 24hrs of continuous soaking. The optical density values are given in the following tables.

Optical Density Retention – Side A, 2 - pass
24hrs, Tap Water

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.31	1.16	1.27	0.87	1.30
15 minutes	1.36	1.22	1.33	0.95	1.21
24 hours	1.26	1.09	1.16	0.84	1.25

Optical Density Retention – Side B, 2 - pass
24hrs, Tap Water

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.28	1.14	1.17	0.83	1.27
15 minutes	1.32	1.20	1.20	0.89	1.30
24 hours	1.25	1.06	1.13	0.77	1.22

In addition to the optical density retention results, a slight amount of bleed was visible off of both the composite and pigment black inks after 24 hours of water soak time. The 24 hour soaked samples had a very minor grainy pattern and the all printed text maintain good optical clarity.

Example 7

Substrate samples were produced in accordance with operational settings outlined in example 2, with the exception of coating sequence and with the coating adjusted from 10% to 7% active solids. Samples were collected after 2, 3 and 4 passes. The coating sequence followed for the 2 pass samples is: Pass #1 (7bcm-face/5bcm-back) + Pass #2 (5bcm-face/7bcm-back). The coating sequence followed for the 3 pass samples is: Pass #1 (7bcm-face/5bcm-back) + Pass #2 (7bcm-face/5bcm-back) + Pass #3 (5bcm-face/7bcm-back). The coating sequence followed for the 4 pass samples is: Pass #1 (7bcm-face/5bcm-back) + Pass #2 (7bcm-face/5bcm-back) + Pass #3 (5bcm-face/7bcm-back) + Pass #4 (5bcm-face/7bcm-back). The samples collected after two, three and four coating passes were converted into 8.5" x 11" sheets, grain long and tested. Test prints were generated off of an HP960C printer, set to best ink jet photo grade matte finish. Both sides of the substrate were printed. The optical density of color bars representing the five primary color/ink types: composite black, cyan, magenta, yellow and pigment black were measured. The printed color bars were submerged in tap water for 15minutes and the resultant optical densities measured. The procedure was then repeated after a total of 24hrs of continuous soaking. The optical density values are given in the following tables.

Optical Density Retention – Side A, 7% solids, 2 - pass
24hrs, Tap Water

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.26	1.12	1.13	0.80	1.21
15 minutes	1.18	1.11	1.05	0.82	1.20

24 hours	1.19	1.03	1.00	0.73	1.18

Optical Density Retention – Side B, 7% solids, 2 - pass
24hrs, Tap Water

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.23	1.13	1.08	0.77	1.22
15 minutes	1.17	1.10	0.97	0.71	1.15
24 hours	1.15	0.98	0.92	0.65	1.14

Optical Density Retention – Side A, 7% solids, 3 - pass
24hrs, Tap Water

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.29	1.14	1.18	0.85	1.28
15 minutes	1.26	1.12	1.11	0.84	1.25
24 hours	1.23	1.05	1.11	0.79	1.24

Optical Density Retention – Side B, 7% solids, 3 - pass
24hrs, Tap Water

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.31	1.16	1.19	0.85	1.29
15 minutes	1.30	1.20	1.14	0.87	1.28
24 hours	1.26	1.07	1.16	0.80	1.27

Optical Density Retention – Side A, 7% solids, 4 - pass
24hrs, Tap Water

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.33	1.16	1.25	0.87	1.33
15 minutes	1.34	1.18	1.23	0.92	1.33
24 hours	1.32	1.11	1.13	0.91	1.31

Optical Density Retention – Side B, 7% solids, 4 - pass
24hrs, Tap Water

Water Soak Time	CMY	Cyan	Magenta	Yellow	Pigment Black
Initial	1.31	1.15	1.21	0.85	1.30
15 minutes	1.30	1.15	1.16	0.90	1.31
24 hours	1.27	1.09	1.15	0.87	1.29

In addition to optical density retention, differences were observed in the print quality following the 24hour tap water soak. The 2 and 3 pass samples became grainy following 24-hour water soak. The grainy appearance was more obvious for the 2-pass sample than for the 3 pass sample. Some bleed was visible off of the composite and pigmented black color bars. Bleed resistance improved as the number of coating passes increased. Bold 10point font that was part of the test print samples, printed in composite black maintained good optical clarity for all three sample types.

Example 8

Two 6,600ft rolls of 10.5mil Teslin TS1000 were sized with coating composition described in example 1, formulated at 12.5% active solids in accordance with operational settings described in example 2. The resultant rolls were converted into 8.5" x 11"sheets, grain long. Test prints were generated off of an HP960C printer, set to best ink jet photo grade matte finish. Both sides of the substrate were printed. Optical density values were measured using an X-Rite® densitometer, model type 418, normalized against a Macbeth® black/white standard plate. Optical densities values are listed in the following table.

Optical Density Values

Sheet Surface	Print Setting	CMY	C	M	Y	K
Side A	Best, Ink Jet Photo Grade Matte Finish	1.38	1.19	1.34	0.93	1.26
Side B	Best, Ink Jet Photo Grade Matte Finish	1.36	1.18	1.33	0.91	1.24

In addition to optical density the prints had excellent overall aesthetics, distinctness of image and quality.

Example 9

A coating composition prepared as in example 1, with the exception that the resultant solids content was 12.5% instead of 10%. The coating composition was applied to a 6,600ft roll of 10.5mil Teslin SP1000 microporous substrate by a flexographic or gravure coating method as described in example 2. The resultant roll was converted into 8.5" x 11"sheets, grain long. Test prints were generated off of an HP960C printer, set to best ink jet photo grade matte finish. Both sides of the substrate were printed. Optical density values were measured using an X-Rite® densitometer, model type 418, normalized against a Macbeth® black/white standard plate. Optical densities values are listed in the following table.

Optical Density Values

Sheet Surface	CMY	C	M	Y	K
Side A	1.41	1.32	1.25	0.89	1.37
Side B	1.38	1.33	1.22	0.88	1.40

In addition to optical density the prints had good overall aesthetics, distinctness of image and quality.

Composite Sheet and Card Fabrication

Example 10 - Hydraulic Platen Lamination (One Composite Sheet)

Sheets 26-inch x 38-inch of treated Teslin TS1000 substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. (Note! This release liner is removed from the composite sheet following lamination and is not an integral part of the final composite sheets.) This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction was placed in a 200-Ton Wabash laminating press, preheated to 220F. The composite construction was compression laminated at a pressure of 200psi for 8minutes at a temperature of 220F. While under press, the platens were cooled to less than 100°F, which took approximately 22minutes. After being removed from the press, the resultant composite sheet was removed from the stack construction. The finished composite sheet had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the resultant 26-inch x 38-inch x 30.5mil composite sheet. The finished cards had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

Example 11 - Hydraulic Platen Lamination (Four Composite Sheets/Book)

Sheets 26-inch x 38-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated twice more so that four pre-pressed multi-layer ply's existed in the stack. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a 200-Ton Wabash laminating press, preheated to 220F. The composite construction was compression laminated at a pressure of 200psi for 8minutes at a temperature of 220F. While under press, the platens were cooled to less than 100°F, which took approximately 22minutes. After being removed from the press, all four composite sheets were removed from the book. All four finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 26-inch x 38-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

Example 12 - Hydraulic Platen Lamination (10 Composite Sheets/Book)

Sheets 26-inch x 38-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated eight more times so that ten pre-pressed multi-layer ply's existed in the stack. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a 200-Ton Wabash laminating press, preheated to 220F. The composite construction was compression laminated at a pressure of 200psi for 8minutes at a temperature of 220F. While under press, the platens were cooled to less than 100°F, which took approximately 22minutes. After being removed from the press, all ten composite sheets were removed from the book. All ten finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 26-inch x 38-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

Example 13 – (10 Composite Sheets/Book, Other Process Conditions)

Sheets 26-inch x 38-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated eight more times so that ten pre-pressed multi-layer ply's existed in the stack. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a 200-Ton Wabash laminating press, preheated to 200°F. The composite construction was compression laminated at a pressure of 180psi for 6minutes at a temperature of 200°F. While under press, the platens were cooled to less than 100°F, which took approximately 18minutes. After being removed from the press, all ten composite sheets were removed from the book. All ten finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 26-inch x 38-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

Example 14 – (10 Composite Sheets/Book, Other Process Conditions)

Sheets 26-inch x 38-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated eight more times so that ten pre-pressed multi-layer ply's existed in the stack. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a 200-Ton Wabash laminating press, preheated to 300°F. The composite construction was compression laminated at a pressure of 250psi for 10minutes at a temperature of 300°F. While under press, the platens were cooled to less than 100°F, which took approximately 25minutes. After being removed from the press, all ten composite sheets were removed from the book. All ten finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 26-inch x 38-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

Example 15 – (7 Composite Sheets/Book, Other Process Conditions)

Sheets 26-inch x 38-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated six more times so that seven pre-pressed multi-layer ply's existed in the stack. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a 200-Ton Wabash laminating press, preheated to 220°F. The composite construction was compression laminated at a pressure of 220psi for 7minutes at a temperature of 220°F. While under press, the platens were cooled to less than 100°F, which took approximately 22minutes. After being removed from the press, all seven composite sheets were removed from the book. All seven finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 26-inch x 38-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

<u>Example 15 – (7 Composite Sheets/Book, Other Process Conditions)</u>

Sheets 26-inch x 38-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated six more times so that seven pre-pressed multi-layer ply's existed in the stack. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a 200-Ton Wabash laminating press, preheated to 220°F. The composite construction was compression laminated at a pressure of 220psi for 7minutes at a temperature of 220°F. While under press, the platens were cooled to less than 100°F, which took approximately 22 minutes. After being removed from the press, all seven composite sheets were removed from the book. All seven finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 26-inch x 38-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

<u>Example 16 – (7 Composite Sheets/Book, Other Process Conditions)</u>

Sheets 26-inch x 38-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated six more times so that seven pre-pressed multi-layer ply's existed in the stack. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a 200-Ton Wabash laminating press, preheated to 200°F. The composite construction was compression laminated at a pressure of 250psi for 7minutes at a temperature of 200°F. While under press, the platens were cooled to less than 100°F, which took approximately 22minutes. After being removed from the press, all seven composite sheets were removed from the book. All seven finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 26-inch x 38-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

Example 16A – (7 Composite Sheets/Book, Other Process Conditions)

Sheets 26-inch x 38-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated six more times so that seven pre-pressed multi-layer plys existed in the stack. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a 200-Ton Wabash laminating press, preheated to 300°F. The composite construction was compression laminated at a pressure of 90psi for 7minutes at a temperature of 300°F. While under press, the platens were cooled to less than 100°F, which took approximately 26minutes. After being removed from the press, all seven composite sheets were removed from the book. All seven finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 26-inch x 38-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

Example 17 – (7 Composite Sheets/Book, Other Process Conditions)

Sheets 26-inch x 38-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated six more times so that seven pre-pressed multi-layer plys existed in the stack. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a 200-Ton Wabash laminating press, preheated to 300°F. The composite construction was compression laminated at a pressure of 250psi for 7minutes at a temperature of 300°F. While under press, the platens were cooled to less than 100°F, which took approximately 26minutes. After being removed from the press, all seven composite sheets were removed from the book. All seven finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 26-inch x 38-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

Example 18 – (7 Composite Sheets/Book, Other Process Conditions - failed)

Sheets 26-inch x 38-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 26-inch x 38-inch sheet of 0.21-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. A sheet 27-inch x 39-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 27" x 39" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated six more times so that seven pre-pressed multi-layer plys existed in the stack. The resultant stack was then placed between two 27" x 39" x 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a 200-Ton Wabash laminating press, preheated to 200°F. The composite construction was compression laminated at a pressure of 90psi for 7minutes at a temperature of 200°F. While under press, the platens were cooled to less than 100°F, which took approximately 20minutes. After being removed from the press, all seven composite sheets were removed from the book. The Teslin/PVC were pealed apart, indicating lack of bond strength. No attempt to fabricate ISO7910 ID-1 cards was made.

Example 19 – (12 Composite Sheets/Book, Other Process Conditions)

Sheets 20-inch x 25-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 20-inch x 25-inch sheet of 0.10-inch polyvinylchloride (PVC), supplied by Empire

Plastics. The PVC sheet was cut in the grain long direction. Below the PVC ply was a second ply of 20-inch x 25-inch x 10mil PVC, cut grain short. Below the 10mil PVC grain short ply was a 20-inch x 25-inch x 2mil PVC sheet cut grain long. A sheet 21-inch x 26-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 21" x 26" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC/PVC/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated ten more times so that twelve pre-pressed multi-layer plys existed in the stack. The resultant stack was placed between buffer pads. The buffer pads are a combination polyamide fiber and mechanical rubber, manufactured and supplied by Yamauchi Corporation, designed to more uniformally distribute temperature and press during thermal lamination. The resultant stack plus buffer pads was then placed between two slightly larger 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a TMP laminating press, preheated to 300°F. The composite construction was compression laminated at a pressure of 203psi for 18minutes at a temperature of 300°F. While under press, the platens were cooled to less than 100°F, which took approximately 19minutes. After being removed from the press, all twelve composite sheets were removed from the book. All twelve finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 20-inch x 25-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

This foregoing example was also conducted using Teslin SP1000 which produced the same results as the Teslin TS1000.

Example 20 – (12 Composite Sheets/Book, Other Process Conditions)

Sheets 20-inch x 25-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 20-inch x 25-inch sheet of 0.10-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. Below the PVC ply was a second ply of 20-inch x 25-inch x 10mil PVC, cut grain short. Below the 10mil PVC grain short ply was a 20-inch x 25-inch x 2mil PVC sheet cut grain long. A sheet 21-inch x 26-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 21" x 26" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC/PVC/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated ten more times so that twelve pre-pressed multi-layer plys existed in the stack. The resultant stack was placed between buffer pads. The resultant stack plus buffer pads was then placed between two slightly larger 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a TMP laminating press, preheated to 250°F. The composite construction was compression laminated at a pressure of 203psi for 18minutes at a temperature of 250°F. While under press, the platens were cooled to less than 100°F, which took approximately 17minutes. After being removed from the press, all twelve composite sheets were removed from the book. The PVC plys from all twelve finished composite sheets were pealed apart. None of the Teslin plys could be delaminated from the adjacent PVC sheet, indicating a good adhesive and seamless bond between the Teslin and the PVC. Since the PVC plys did not laminate, no attempt to fabricate ISO7910 ID-1 cards was made.

<u>Example 21 – (12 Composite Sheets/Book, Other Lay-up Pattern and Process Conditions)</u>

Sheets 20-inch x 25-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain short direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 20-inch x 25-inch sheet of 0.10-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain short direction. Below the PVC ply was a second ply of 20-inch x 25-inch x 10mil PVC, cut grain long. Below the 10mil PVC grain short ply was a 20-inch x 25-inch x 2mil PVC sheet cut grain long. A sheet 21-inch x 26-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 21" x 26" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC/PVC/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated ten more times so that twelve pre-pressed multi-layer plys existed in the stack. The resultant stack was placed between buffer pads. The resultant stack plus buffer pads was then placed between two slightly larger 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a TMP laminating press, preheated to 300°F. The composite construction was compression laminated at a pressure of 203psi for 18minutes at a temperature of 300°F. While under press, the platens were cooled to less than 100°F, which took approximately 19minutes. After being removed from the press, all twelve composite sheets were removed from the book. All twelve finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 20-inch x 25-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any

attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

Example 22 – (12 Composite Sheets/Book, Other Lay-up Pattern and Process Conditions - failed)

Sheets 20-inch x 25-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain short direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 20-inch x 25-inch sheet of 0.10-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain short direction. Below the PVC ply was a second ply of 20-inch x 25-inch x 10mil PVC, cut grain long. Below the 10mil PVC grain short ply was a 20-inch x 25-inch x 2mil PVC sheet cut grain long. A sheet 21-inch x 26-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 21" x 26" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC/PVC/PVC lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated ten more times so that twelve pre-pressed multi-layer plys existed in the stack. The resultant stack was placed between buffer pads. The resultant stack plus buffer pads was then placed between two slightly larger 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a TMP laminating press, preheated to 250°F. The composite construction was compression laminated at a pressure of 203psi for 18minutes at a temperature of 250°F. While under press, the platens were cooled to less than 100°F, which took approximately 17minutes. After being removed from the press, all twelve composite sheets were removed from the book. The PVC plys from all twelve finished composite sheets were pealed apart. None of the Teslin plys could be delaminated from the adjacent PVC sheet, indicating a good

adhesive and seamless bond between the Teslin and the PVC. Since the PVC plys did not laminate, no attempt to fabricate ISO7910 ID-1 cards was made.

Example 23 – (12 Composite Sheets/Book, Magnetic Stripe Version)

Sheets 20-inch x 25-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 20-inch x 25-inch sheet of 0.10-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. Below the PVC ply was a second ply of 20-inch x 25-inch x 10mil PVC, cut grain short. Below the 10mil PVC grain short ply was a 20-inch x 25-inch x 2mil PVC Magnetic Stripe master sheet, fabricated with the magnetic stripe running parallel to the short (20") dimension of the sheet. The magnetic stripes were 3 level, 2750 coercivity type. A sheet 21-inch x 26-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 21" x 26" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC/PVC/magnetic stripe master sheet lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated ten more times so that twelve pre-pressed multi-layer plys existed in the stack. The resultant stack was placed between buffer pads. The resultant stack plus buffer pads was then placed between two slightly larger 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a TMP laminating press, preheated to 300°F. The composite construction was compression laminated at a pressure of 203psi for 18minutes at a temperature of 300°F. While under press, the platens were cooled to less than 100°F, which took approximately 19minutes. After being removed from the press, all twelve composite sheets were removed from the book. All twelve finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and

seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 20-inch x 25-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

Example 24 – (12 Composite Sheets/Book, Magnetic Stripe Version)

Sheets 20-inch x 25-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain short direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 20-inch x 25-inch sheet of 0.10-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain short direction. Below the PVC ply was a second ply of 20-inch x 25-inch x 10mil PVC, cut grain long. Below the 10mil PVC grain short ply was a 20-inch x 25-inch x 2mil PVC Magnetic Stripe master sheet, fabricated with the magnetic stripe running parallel to the short (20") dimension of the sheet. The magnetic stripes were 3 level, 2750 coercivity type. A sheet 21-inch x 26-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 21" x 26" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC/PVC/magnetic stripe master sheet lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated ten more times so that twelve pre-pressed multi-layer plys existed in the stack. The resultant stack was placed between buffer pads. The resultant stack plus buffer pads was then placed between two slightly larger 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a TMP laminating press, preheated to 300°F. The composite construction was compression laminated at a pressure of 203psi for 18minutes at a temperature of 300°F. While under press, the platens were cooled to less than 100°F, which took approximately 19minutes. After being

removed from the press, all twelve composite sheets were removed from the book. All twelve finished composite sheets had good integrity; any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. ISO7910 ID-1 cards were die cut from the each of the 20-inch x 25-inch x 30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC.

<u>Example 25 – (12 Composite Sheets/Book, Magnetic Stripe Version - failed)</u>

Sheets 20-inch x 25-inch of treated Teslin substrate, 10.5mils thick, were cut from a master roll in the grain long direction. The Teslin had been coated with 3 passes on each side (3x3) using the same coating composition as described in example 1 and the same Flexographic coating technology described in example 2. One coated Teslin sheet was placed on top of one 20-inch x 25-inch sheet of 0.10-inch polyvinylchloride (PVC), supplied by Empire Plastics. The PVC sheet was cut in the grain long direction. Below the PVC ply was a second ply of 20-inch x 25-inch x 10mil PVC, cut grain short. Below the 10mil PVC grain short ply was a 20-inch x 25-inch x 2mil PVC Magnetic Stripe master sheet, fabricated with the magnetic stripe running parallel to the short (20") dimension of the sheet. The magnetic stripes were 3 level, 2750 coercivity type. A sheet 21-inch x 26-inch of 2-mil clear polyester was placed over the Teslin sheet to act as a release liner. This construction was placed between two 21" x 26" x 30mil polished stainless steel metal plate. An identical polyester/treated Teslin sheet/PVC/PVC/magnetic stripe master sheet lay-up was placed on top of a stainless plate from the existing construction. A polished metal plate was placed over the exposed polyester release liner. The pattern was repeated ten more times so that twelve pre-pressed multi-layer plys existed in the stack. The resultant stack was placed between buffer pads. The resultant stack plus buffer pads was then placed between two slightly larger 125mil un-polished non-corrosive metal plates. This entire construction, referred to as a book, was placed in a TMP laminating press, preheated to 250°F. The

composite construction was compression laminated at a pressure of 203psi for 18minutes at a temperature of 250°F. While under press, the platens were cooled to less than 100°F, which took approximately 17minutes. After being removed from the press, all twelve composite sheets were removed from the book. The PVC plys from all twelve finished composite sheets were pealed apart. None of the Teslin plys could be delaminated from the adjacent PVC sheet, indicating a good adhesive and seamless bond between the Teslin and the PVC. Since the PVC plys did not laminate, no attempt to fabricate ISO7910 ID-1 cards was made.

<u>Example 26 (Conditioning of Cards/Composite Sheets)</u>

Cards fabricated according to example 19, were individually soaked in deionized water for 15minutes then allowed air dry for 24 hours. Resultant conditioned cards demonstrated easier separation from a stack and slip characteristics compared to the unconditioned version.

<u>Example 27 (Conditioning of Cards/Composite Sheets)</u>

Cards fabricated according to example 19, were individually conditioned at 75% RH and 25C for 16hours. Resultant conditioned cards demonstrated easier separation from a stack and slip characteristics compared to the unconditioned version.

<u>Example 28 (Conditioning of Cards/Composite Sheets)</u>

Cards fabricated according to example 19, were conditioned at 75% RH and 25C for 16hours in a stack. Resultant conditioned cards did not demonstrated easier separation from a stack and slip characteristics compared to the unconditioned version.

<u>Example 29 (Conditioning of Cards/Composite Sheets)</u>

Composite sheets fabricated according to example 19, were individually soaked in deionized water for 15minutes then allowed air dry for 24 hours. ISO7910 ID-1 cards were die cut from the each of the 20-inch x 25-inch x

30.5mil composite sheets. The finished cards from each composite sheet had good integrity and good lat flat. Any attempt to delaminate destroyed the Teslin layer, which demonstrated a good adhesive and seamless bond between the Teslin and the PVC. Resultant conditioned cards demonstrated easier separation from a stack and slip characteristics compared to the unconditioned version.

The following table compares the optical density retention performance of the new offering (8181-67-09 recipe) to standard IJ1000WP (2 component recipe). Test print patterns used in this study were produced off of an HP970 color inkjet printer, set on best quality and photo grade ink jet glossy paper.

Optical Density following De-Ionized Water Soak

	Soak Time (hrs)	Composite Black	Cyan	Magenta	Yellow	Pigmented Black
Std. Teslin IJ1000WP	0	1.26	1.2	1.18	0.86	1.25
	24	1.21	1.13	1.03	0.74	1.19
	96	1.18	1.08	1.03	0.71	1.17
New Teslin IJ1000WP (8181-67-09)	0	1.39	1.33	1.22	0.91	1.37
	24	1.39	1.35	1.29	0.92	1.37
	96	1.39	1.32	1.31	0.92	1.36

The invention has been described with reference to specific embodiments. Obvious modifications and alterations will occur to others upon reading and understanding the detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the invention or the equivalents thereof.